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LASE Data acquired during CAMEX-4 (The Fourth Convective and Moisture Experiment)

1. Contacts

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2. Instrument Description

LASE is an airborne DIAL (Differential Absorption Lidar) system used to measure water vapor, aerosols, and clouds throughout the troposphere. This system uses a double-pulsed Ti:sapphire laser, which is pumped by a frequency-doubled flashlamp-pumped Nd:YAG laser, to transmit light in the 815-nm absorption band of water vapor. The Ti:sapphire laser wavelength is controlled by injection seeding with a diode laser that is frequency locked to a water vapor line using an absorption cell. LASE operates by locking to a strong water vapor line and electronically tuning to any spectral position on the absorption line to choose the suitable absorption cross-section for optimum measurements over a range of water vapor concentrations in the atmosphere. During CAMEX-4, LASE operated from the NASA DC-8 using strong and weak water vapor lines in both the nadir and zenith modes, thereby simultaneously acquiring data below and above the aircraft. The strongly absorbing, temperature insensitive water vapor line at 817.2231 nm (12236.5603 cm^{-1}) with a line strength of 4.060E-23 cm, linewidth of 0.0839 cm^{-1}, and lower energy state of 224.838 cm^{-1} was used during CAMEX-4. Line strength accuracy is estimated to be 2% and linewidths have agreed with other measurement to within 2% giving an overall accuracy of absorption cross-section of less than 3% (Poinsardin and Browell, 1997). Effective absorption cross-section profiles were calculated at the on-line and off-line wavelengths and the side-line positions, and corrections for Doppler broadening, pressure shift, water vapor line width, spectral purity, molecular density, and aerosol scattering ratio were used in water vapor mixing ratio retrievals (Ismail et al., 1989).

Absolute water vapor distributions will be derived from the LASE measurements across the troposphere from 0-14 km over a mixing ratio range of about 20 g/kg to 0.01 g/kg. The initial archive contains only the nadir water vapor distributions. The LASE nadir water vapor profiles have a vertical resolution of 330 m. For all flights, the LASE nadir water vapor profiles have a temporal averaging period of 3 minutes, which corresponds to a horizontal distance of about 42 km. Other temporal averaging periods can be produced upon request. Previous water vapor comparisons have shown the LASE water vapor mixing ratio measurements have an accuracy of better than 6% or 0.01 g/kg, whichever is larger, across the troposphere (Browell et al., 1997).

In addition to measuring water vapor mixing ratio profiles, LASE simultaneously measures aerosol backscattering profiles at the off-line wavelength near 815 nm. Profiles of the aerosol scattering ratio, defined as the ratio of aerosol scattering to molecular scattering, are determined

by normalizing the scattering in the region containing enhanced aerosol scattering to the expected scattering by the "clean" (molecular only) atmosphere at that altitude. For these CAMEX-4 measurements, the LASE nadir and zenith aerosol scattering ratio profiles have a vertical resolution of 60 m for all nadir measurements and for zenith measurements in flights 8, 10, 11, and 12 (zenith measurements in all other flights have a resolution of 2 km due to extensive clouds). Both nadir and zenith aerosol scattering ratio profiles have a horizontal resolution of 9 seconds (~2.1 km).

3. LASE CAMEX-4 Measurements

NASA's Lidar Atmospheric Sensing Experiment (LASE) system was operated during the the Fourth Convective and Moisture Experiment (CAMEX-4) to characterize water vapor fields in the vicinity of hurricanes. While remote sensing of the hurricane environment was the primary objective of CAMEX-4, there were also separate flights to study thunderstorm structure, precipitation systems, and atmospheric water vapor profiles. This portion of CAMEX-4 was known as KAMP, Keys Area Microphysics Project. The objective of the KAMP flights was to improve quantitative precipitation estimates from passive and active microwave instruments. LASE was operated during both CAMEX-4 and KAMP.

LASE was operated from the NASA DC-8 aircraft in the nadir and zenith modes simultaneously. Six DC-8 flights were made in the vicinity of hurricanes and four KAMP flights were made into areas of heavy rain convection. In addition, there were two instrument check flights and one calibration flight over the Andros Island site during the CAMEX-4 period between August 18 and September 24, 2001. LASE collected profile data using a combination of three water vapor absorption cross-sections over a period of more than 70 hours.

An example of LASE Aerosol and water vapor measurements acquired during DC-8 Flight 13, in the vicinity of Hurricane Erin are shown in Figure 1. The flight track depicts the circumnavigation of the hurricane to acquire high resolution moisture profiles throughout the storm environment, as described in the CAMEX-4 Optimal Data Assimilation flight plan.

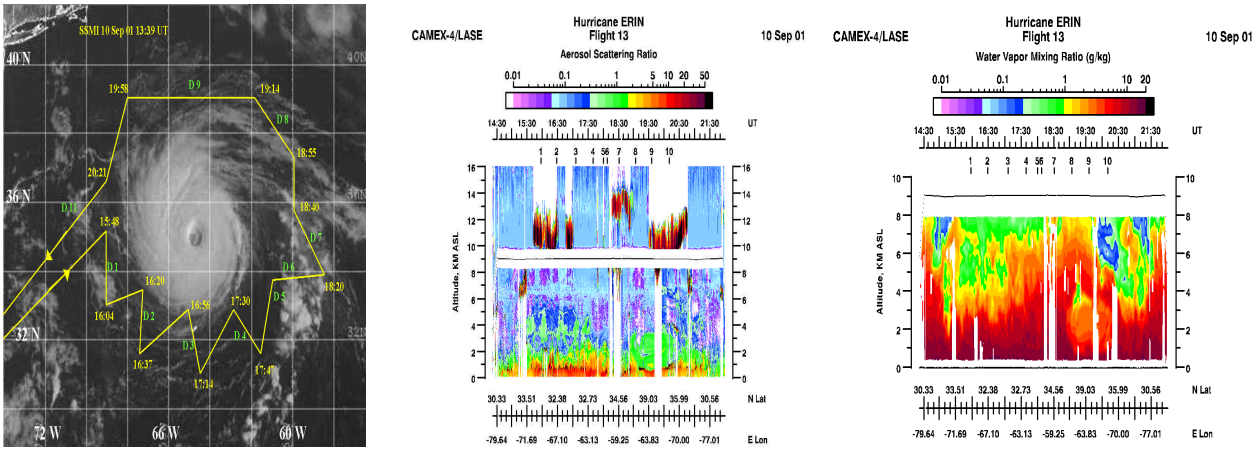

Figure 1: Visible satellite image at 13:39 UT on September 10, 2001 showing DC-8 flight track around Hurricane Erin (left), LASE aerosol scattering ratio (center), and water vapor mixing ratio (right) measured during this flight.

4. References

Browell, E.V., S. Ismail, W.M. Hall, A.S. Moore, Jr., S.A. Kooi, V.G. Brackett, M.B. Clayton, J.D.W. Barrick, F.J. Schmidlin, N.S. Higdon, S.H Melfi, and D.N. Whiteman, LASE validation experiment, in Advances in Atmospheric Remote Sensing with Lidar, A. Ansmann, R. Neuber, P. Rairoux, and U. Wandinger, eds., Springer-Verlag, Berlin, 289-295, (1997).

Ismail, S., E. V. Browell, 1989: Airborne and spaceborne lidar measurements of water vapor profiles: A sensitivity analysis, *Appl. Opt.*, **28**, 3603-3615.

Ponsardin, P.L. and Browell, E.V., Measurements of $H_2{}^{16}O$ Linestrengths and Air-Induced Broadenings and Shifts in the 815-nm Spectral Regions, Journal of Molecular Spectroscopy 185, 58-70(1997), Article No. MS977354.

5. LASE CAMEX-4 URL: http://asd-www.larc.nasa.gov/lidar/cmx4/camex4.html

6. LASE CAMEX-4 data set release history

a. "Quick-look", preliminary data

These data were produced and distributed during the CAMEX-4 field mission during August - September 2001. These are for "quick-look" purposes only.

b. "Final"

These data completed post-processing in May 2002 and contained both nadir and zenith aerosols and nadir water vapor profiles. Zenith water vapor are still undergoing post processing and will be archived in the future.

7. Content of ascii data and image files and naming conventions

a. Data Files

bcYYYYMMDD.cm4, [aerosol scattering ratio, YYYY= year, MM= month, DD= day]
wcYYYYMMDD.cm4, [water vapor, YYYY= year, MM= month, DD= day]

b. GIF Image Files

Log scale : cm4_NN_SSS_logy.gif, [image, NN = DC-8 flight number, SSS = asr, scattering ratio or SSS = h2o, water vapor, y = image segment consecutive number, (no number indicates entire flight image)]

Linear scale : cm4_NN_h2oy.gif, [image, NN = DC-8 flight number, y = image segment consecutive number, (no number indicates entire flight image)]

Note: Flights 01, 02, 03, and 04 were test flights at NASA Dryden Flight Research Center
Flight 05 - Transit: Dryden to NAS JAX - August 15, 2001
Flight 06 - Andros Island Overflight - August 18, 2001
Flight 07 - Chantel Overflight - August 20, 2001
Flight 08 - Instrument Test Flight - August 25, 2001
Flight 09 - KAMP Flight #1 - September 03, 2001
Flight 10 - Instrument Check/Convection - September 06, 2001 (Note: Water vapor was not post processed for this flight due to extensive clouds)
Flight 11 - KAMP Flight #2 - September 07, 2001
Flight 12 - Kamp Flight #3 - September 09, 2001
Flight 13 - Hurricane ERIN #1- September 10, 2001

Flight 14 - TS GABRIELLE #1 - September 15, 2001
Flight 15 - KAMP Flight #4 - September 19, 2001
Flight 16 - TD10 - TS HUMBERTO #1 - September 22, 2001
Flight 17 - Hurricane HUMBERTO - COVES #1 - September 23, 2001
Flight 18 - Hurricane HUMBERTO - COVES #2 - September 24, 2001

8. Content of directories on CAMEX-4 archive

Parent/assigned directory -- final nadir water vapor and aerosol data and images (May, 2002)

bcYYYYMMDD.cm4	data: final aerosol scattering ratio
wcYYYYMMDD.cm4	data: final water vapor mixing ratio
cm4_NN_SSS_logy.gif	Logrithmic ASR and Water Vapor images
cm4_NN_h2oy.gif	Linear Water Vapor images

9. Data file archive format

Format specification for Data Exchange by Steve E. Gaines and R. Stephen Hipskind found at http://cloud1.arc.nasa.gov/solve/archiv/archive.tutorial.html. LASE uses format number 2310.

10. IDL 2310 format read code

The following IDL program (attached) , "rd_cm4_2310.pro" will read the 2310 formatted aerosol and water vapor profile data.

11. Algorithm for data reduction

Water vapor employs the DIAL technique, which is explained at http://asd-www.larc.nasa.gov/lidar/concept.html and instrument description (item 2 above). Aerosol scattering ratio computations are described in instrument description (item 2 above).

12. Location of data collection

08/15/2001 - 09/24/2001 in region centered off the South Eastern Coast of the United States from North Carolina to the Caribbean Sea, and the Gulf of Mexico.

13. Temporal and vertical resolution of data

Data Intervals
- Water vapor and aerosol horizontal data interval is 9 seconds or 2.1 km
- Water vapor and aerosol vertical data interval is 30 m

Data Resolution (Averaging Interval)
- Nadir water vapor horizontal resolution is 3 minutes or 42 km
- Nadir water vapor vertical resolution is 330 m
- Nadir aerosol scattering ratio vertical resolution is 60 m
- Zenith aerosol scattering ratio vertical resolution is 60 m for flights 8, 10, 11, and 12 (all other flights have zenith vertical resolution of 2 km).